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Intermodality on the Emergence of Mega-Urban Regions: Principles and Equations

by

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Intermodality in the Emergence of Mega-Urban Regions: Principles and Equations[1,2]

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Abstract: Intermodality occurs in a three dimensional transportation space where the first dimension is the spatial entities (points), the second dimension is the modal interactions, and the third dimension is the intermodal interactions. The global objective of operators is to minimize transportation time and/or costs. This involves the selection of a set of transportation chains that presents the least travel time and/or cost over all the potential transportation chains. Intermodality offers a partial answer to the objective of minimization of time and costs by permitting a higher fluidity of movements. Intermodal infrastructures are at the base of the development of mega-urban regions because they are the only locations where a link from a regional urban system towards other economic entities is possible.
Key Words: Transportation, Intermodality, Modelling, Urbanization.

Résumé: L'intermodalité se déroule dans un espace de transport tri-dimensionnel où la première dimension est les entités spatiales (points), la seconde dimension est les interactions modales, et la troisième dimension est les interactions intermodales. L'objectif global des opérateurs est de minimiser les coûts et/ou le temps de transport. Ceci implique la sélection d'une chaîne de transport qui présente le plus petit temps et/ou coût de parcours sur un ensemble de chaînes de transport. L'intermodalité offre une réponse partielle à l'objectif de minimiser le temps et les coûts en permettant une plus grande fluidité des mouvements. Les infrastructures intermodales sont à la base du développement de méga-régions urbaines parce qu'elles sont les seuls lieux où un lien entre un système urbain régional et d'autres entités économique est possible.
Mots Clés: Transport, Intermodalité, Modélisation, Urbanisation.

1. Introduction

The importance of intermodality to attain efficiency is well established. For instance, the use of containers shows the complementarity between transportation modes for the traffic of goods by offering a higher fluidity to movements and a standardization of loads. Intermodality permits large economies of scale within a transportation system. Another major innovation for the flows of goods is the development of fast and high capacity linkages. The travel time as well as the travel cost take a decisive importance in the globalization of trade and consequently in transportation. This is reinforced by the "just in time" type of production that requires low inventory levels and important movements inside large economic areas between multiple points of origin and destination. With the development of new transportation and intermodal infrastructures, urban and non-urban areas alike have a more important accessibility level to the global market. Changes in the transportation network bring about important changes in the structure of urban systems. Those urban systems are strongly affected by new conditions of the economy that are simultaneously affecting the multimodal transportation system.

This paper aims to give a new perspective on urbanization by integrating the concept of intermodality to the development of large economic areas defined as mega-urban regions, and to contribute to the understanding of the relationships between transportation and land use. The following text shows the main tendencies of modern transportation to verify the relationships between the modes and to present a definition of intermodality in emerging East Asian mega-urban regions. The objective is to demonstrate the hypothesis according to which the modal and intermodal capacities of the multimodal transportation system have a predominant role in the structuring of mega-

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urban regions. First, the context and definition of mega-urban regions in East Asia is presented. Second, an assessment of intermodality is undertaken. A particular attention is made on the geometry of intermodality to understand the network factors that are affecting the spatial elements of multimodal transportation system. An equation to measure the efficiency of the multimodal transportation system is proposed. Finally, the role of intermodality in the emergence of mega-urban regions in China is introduced.

2. The Emergence of Mega-Urban Regions

The mega-urban region is a derived notion of the megalopolis. According to the definition of Gottmann (1961) in the North American context, the megalopolis is a set of metropolitan areas and cities mixed with zones of low density of land use along a transportation corridor. The impact of the North American megalopolis over its interurban areas has been light because of the density of land use in those areas. The process of emergence of mega-urban regions in East Asia occurs in a totally different spatial and historical context. The areas between the urban centres are characterized by a high density of rural land use. The influence of East Asian cities on their high density interurban areas is far more important than those of Occidental cities. There is a stronger possibility of economic development in rural areas based on the use of a vast pool of labour and on the development of a potential market of several million consumers. Within the main interurban transportation axes there is the emergence of non-rural activities such as commerce and industrial production in formally rural areas causing a strong transportation demand. McGee (1991,1989) defines these high density intermetropolitan spaces by the term *desakota* where *desa* means village and *kota* town and by *kotadesasi* the processes related to the emergence of those zones that are basically an urban transition within rural areas.

A mega-urban region is an economic space composed of several large urban centres oriented along transportation corridors that give a regional cohesion. We can consider a mega-urban region as a fuzzy space where the spatial extent is not absolute but uncertain (Rolland-May, 1987). The more an urban system is developed and linked with efficient transportation infrastructures, the more intermetropolitan areas will have economic activities other than rural. In the particular East Asian context, there is a greater possibility of economic development along the interurban corridors and transportation axes because of the high density of land use. Economic changes in *desakota* regions have more impacts on dense and structured interurban areas than low density unstructured areas. Zhou (1991) has developed the notion of metropolitan interlocking regions to explain the process of large scale urbanization in China. He denotes five basic conditions for the emergence of metropolitan interlocking regions: 1) Two or more cities of more than one million inhabitants. 2) Important port infrastructures. 3) Axes of communication that act as corridors of economic development. 4) Several small and middle size urban centres along the corridors. 5) Intensive economic interactions between urban and rural areas. Considering those conditions, we prefer to use the term mega-urban regions instead of metropolitan interlocking regions. The first addresses the region as an emerging urbanized entity while the second put the emphasis on metropolitan areas and the linkages between them, which is only a part of the urban system.

Starting from McGee's and Zhou's definitions, the transport dimension inside the East Asian mega-urban regions is characterized by: 1) The emergence of the informal transportation sector is occurring in urban as well as rural areas. Informal transportation was developed to face the inadequacy of the modern transportation sector to respond to an increasing demand of mobility of people and commodities. 2) We see important traffic of people and goods along transportation axes between metropolitan areas. There is an emergence of transportation axes between the metropolitan centres where economic development and land use changes occur. 3) There is an increasing share of road transportation over the total transportation sector. The dynamic of the international economy is more oriented toward the development of the light industrial sector. This sector, characterized by movements of goods between several points of origin and destination, and by small shipments, cannot be efficient without the road sector. 4) There is intensive interactions of people and goods between rural and urban areas. The emergence of economic activities in the *desakota* regions raises their interactions with urban areas. 5) The development of high capacity modern transportation infrastructures is occurring at the inter and intra-urban levels and is simultaneous to the economic development. However, its seems that those developments are a response to congestions in existing axes rather than an initiator of economic growth. 6) There is the development of large intermodal infrastructures for the international and regional transit of persons and particularly of goods. A mega-urban region cannot be a closed system and the international traffic transits by limited metropolitan areas equipped with intermodal infrastructures, principally ports.

Figure 2.1 shows the spatial pattern and land use of an East Asian country (from McGee, 1991). The coastal regions are generally the most urbanized because of their higher accessibility level. There are six major land use types in this spatial system: 1) Major cities of the urban system that are often dominated by one or two large metropolitan areas. 2) The peri-urban regions within the pendular migration limits, a 30 km diameter from the central city. 3) *Desakota* regions that are a blend of agricultural and non-agricultural land uses. Those spaces are principally oriented along transportation corridors with a high accessibility level. 4) High density rural areas that still occupy an important part of the space and that experience modernizations in agricultural production techniques. 5) Low density spaces that present varied possibilities for urban and rural development. 6) Mega-urban regions that are a set of metropolitan areas, peri-urban spaces, *desakota* regions and in a lesser part, high density rural areas.

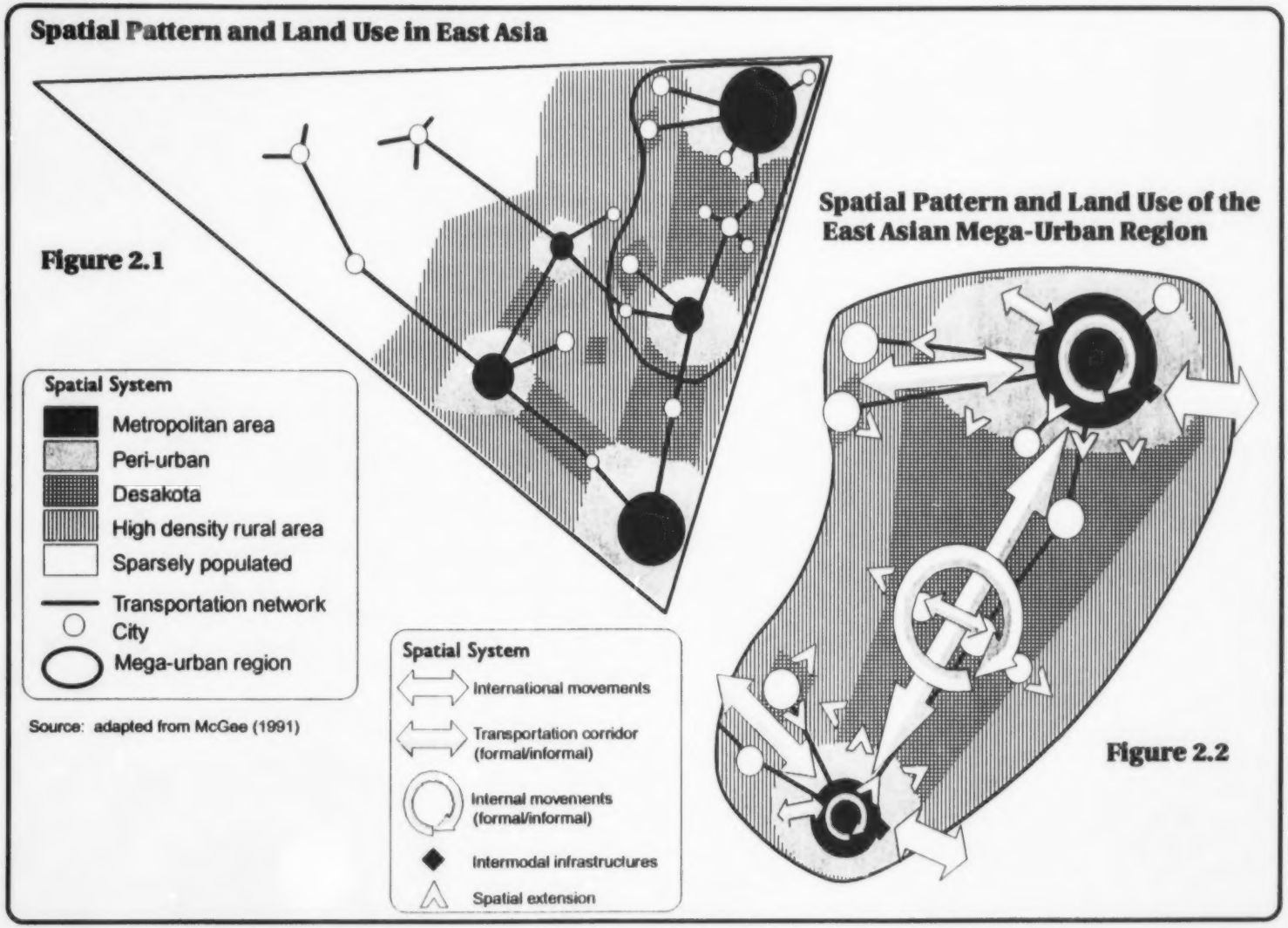
Figure 2.2 shows the spatial pattern and land use of the mega-urban region. Large transportation axes are oriented between the cities and the metropolitan areas where transportation modes are linked to rail, road and maritime sectors. Deltaic mega-urban regions facilitate the maritime sector through the presence of a penetration axe with several rivers and canals. A part of movements are taken in charge by the informal sector, particularly by road transportation. Along major axes there is the emergence of *desakota* land use where one of the main characteristic is the growth of internal movements and mobility. Parallel to this dynamic of movements, there is a spatial dynamic axed toward extension, densification and transformation of land use. The growth of mobility and accessibility levels, the accumulation of economic activities and demographic pressures transforms the mega-urban region by land use changes (Paderanga, 1990). Cities are extending, as their peri-urban areas, and new rural areas are becoming *desakota* regions. Most of the time we don't know where urban space ends and where rural space begins. In mega-urban regions several types of land uses follow the influences of a complex system of supply and demand of transportation. The mobility demand ranges from low for rural areas to very high in urban areas. From the supply point of view, it can range according to the capacities of transportation networks. When supply does not fulfil the demand congestion occurs. One planning objective is to equip land use zones with proper transportation infrastructures in order to cope with the mobility demand of each type of land use. This strategy is integrated in the transportation/land use optimization concept.

Mega-urban regions are structured along corridors of economic development. Considering the example of megalopolises, urbanization has always occurred along main communication axes. The corridor structures the mega-urban region and is defined by the following elements: 1) A set of cities of varied sizes where the large metropolitan areas act as hub centres. 2) Transportation networks that link the cities in an urban system where major urban centres are intermodal points. 3) An adjacent space to the transportation axes that is influenced by the growth of accessibility and mobility. This space is proper to the emergence of *desakota* regions if that process has not already occurred. 4) Movements of persons and goods on the transportation axes. Land use changes along a corridor are proportional to the intensity of movements.

3. Intermodality: Principles and Equations

One of the main tendencies of the international transportation system is the spatial distribution of transportation modes. While the location of the maritime transportation is delimited, air and road transportation systems are less restricted by physical constraints. All types of transportation infrastructures aim to avoid discontinuity between economic entities, especially between place of production and consumption. A recognition of the concept of intermodality enables the organization of more balanced relationships between transportation modes in the context of a long term planning and investments. Intermodality implies a combined territorial infrastructure and the development of transportation techniques with adaptability as the main goal. Conditions of the economy change, so the multimodal transportation network must cope with those changes. The growth of networks densities and particularly of the intensity of movements is at the root of the process of territorial development. The fast progress of land, maritime and air traffic at the global scale requires an examination of intermodal transportation system planning. The role of intermodality as an intermediate infrastructure between transportation modes profits all transportation means. Infrastructures are constantly developing, linking hinterland to coastal areas, and coastal areas to other coastal areas. Intermodal points are created at the crossroad of transportation modes. The concept of economies of scale and management of flows tend to decrease the number of those points.

Intermodality can be illustrated under a graphic form and is a method to quantify the efficiency of use of combined transportation modes. The limits of intermodality are imposed by factors of space, time, form, pattern of


Spatial Pattern and Land Use in East Asia
Figure 2.1
Spatial System
Metropolitan area
Peri-urban
Desakota
High density rural area
Sparsely populated
Transportation network
City
Mega-urban region
Source: adapted from McGee (1991)
Spatial System
International movements
Transportation corridor (formal/informal)
Internal movements (formal/informal)
Intermodal infrastructures
Spatial extension
Spatial Pattern and Land Use of the East Asian Mega-Urban Region
Figure 2.2

the network, the number of points and arcs, and the type and characteristic of the vehicles and terminals. Intermodality can be conceived as the transition from one mode of transportation to another, and is organized around the followings concepts: 1) The nature and quantity of the transported commodities; 2) The modes of transportation that are used; 3) The origins and destinations; 4) Transportation time and costs; 5) The value of the commodities and the frequencies of the shipments. Two notions help define intermodality on a multimodal network. First the geometrical aspects that identify the graphical characteristics of the network, and second the operational aspects that explain the movements inside the network.

3.1 Geometrical Definition of the Multimodal Network

We consider on a territory (area) a set of cities (points) linked by transportation infrastructures (arcs). The collection of those arcs that connect the points over an area form an undirected transportation network which may contain several cycles. Figure 3.1 presents three networks each having their arcs and points, networks R^K, R^L and R^M. A network represented by one mode of transportation is a modal network. For each modal network, an arc has a capacity, a travel time and a cost of use. Certain cities have infrastructures that permit the flow of goods and/or passengers from one transportation mode to another. This flow capacity is defined as an intermodal arc between two modal networks. An intermodal arc has a capacity, a transfer time and a cost of use. For reasons of simplicity, lets define movements of goods and passengers as movements of unities. If an unity must transit from one point to another, then the set of arcs used for the movement between those points represents a transportation chain. A potential transportation chain is the set of all possible arcs linking points to other points over which an unity can transit. The transportation chain is therefore the path optimization between two point through the choice of a given path inside a set of potential transportation chains. Sometimes, there is only one potential transportation chain. On figure 3.1, the transportation chain between city *g* and city *b* has an intermodal point *e*. There is intermodality because the *g-e-c-b* path is more efficient (shorter and/or less costly depending on what kind of efficiency is considered) than the *g-e-b* path or any other path that is multimodal or not. The set of these geometrical elements can be expressed with mathematical formulations. A modal network R^K is a set of points $(a,b,...,n)$ linked by arcs (V_{ab}^K), that is:

$$R^k = \{N, V\} \text{ or}$$
$$R^K = \left\{\{a,b,\ldots,n\}\ ,\ \{V_{ab}^K, V_{ac}^K, \ldots, V_{mn}^K\}\right\} \quad (1)$$

Each point has a geographical coordinate and each arc implies a path from one point to another. On the modal network R^K (see figure 3.1), the set of paths to move from point *a* to point *c* can be *a-c* or *a-b-c*. There is no transportation networks without movements, so the modal network R^K must be considered through movements (or interactions) between points. Therefore, equation 1 becomes:

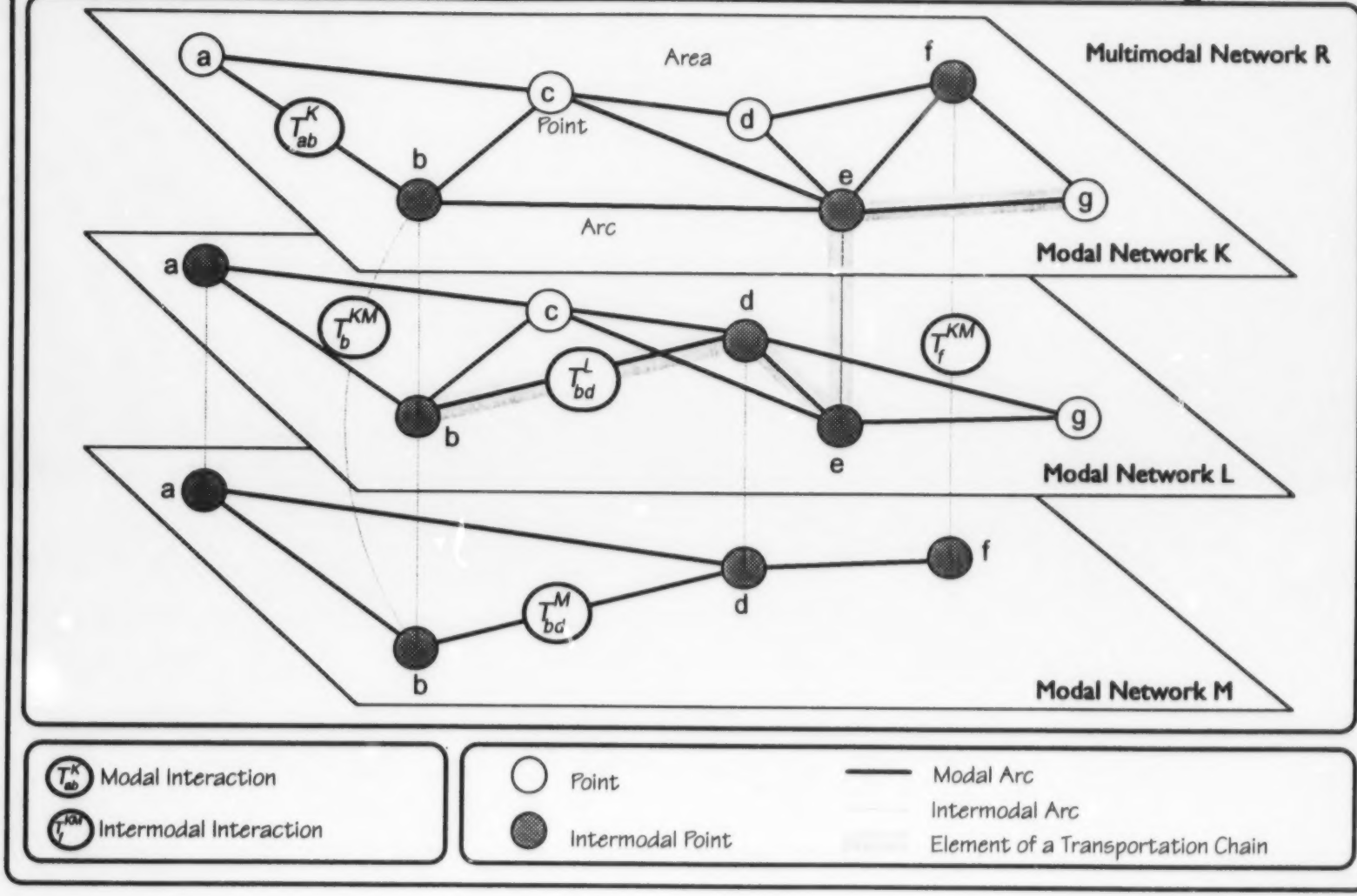
$$R^K = \left\{\{a,b,\ldots,n\}\ ,\ \{T_{ab}^K, T_{ac}^K, \ldots, T_{mn}^K\}\right\} \quad (2)$$

where T_{ab}^K is the interaction between points *a* and *b* on the modal network *K*. This adds more information to the definition of the modal network because an interaction represents at the same time a path and a flow through that path. The flow has an intensity and a direction, so an T_{ab}^K arc can exists at the same time than an T_{ba}^K arc. If an unity moves from a modal network R^K to a modal network R^L at an intermodal point *a* that belongs to both networks, then this movement is expressed by an intermodal interaction T_a^{KL} on an intermodal arc V_a^{KL} (see figure 3.1). Lets consider the set of movements inside and between the modal networks that form a multimodal transportation network *R*:

$$R \supset R^X \ \forall\ X \quad (3)$$

by:

Principles of Intermodality **Figure 3.1**



$$R = \left\{ \{a, b, \ldots, n\} \ , \ \{T^X_{ab}, T^X_{ac}, \ldots, T^X_{mn}\} \ , \ \{T^{XY}_a, T^{XY}_b, \ldots, T^{XY}_n\} \ \forall \ X \right\} \tag{4}$$

The multimodal network R contains all the modal networks R^X for all modes X. R is a three dimension network where the first dimension is the spatial entities (points), the second dimension is the modal interactions, and the third dimension is the intermodal interactions. Therefore, a multimodal network contains a set of points linked by modal and intermodal movements. This leads us to an operational definition.

3.2 Operational Definition of Intermodality

Operational implications of intermodality cannot be conceived without movements from a point of origin to a point of destination. The objective is not here to explain why movements are generated, but we acknowledge that the movements generated by an economic entity is proportional to its level of economic development. There are several possible paths over which movements can occur. A potential transportation chain $\{a \rightarrow b\}^*$ is the set of all possible paths between point a and b on a multimodal network R:

$$\{a \rightarrow b\}^* \subset R \tag{5}$$

while a transportation chain is the path used for a movement between a and b from a set of potential transportation chains on a multimodal network R:

$$\{a \rightarrow b\} \subset \{a \rightarrow b\}^* \subset R \tag{6}$$

This equation requires that all potential transportation chains must be found. On a complex multimodal transportation network, this objective is difficult to attain on computational basis because of combinational explosion. The number of transportation chains grows exponentially with the number of arcs. However, methodologies in artificial intelligence like heuristic search give solutions to that problems with algorithms like the A* (Chabris, 1989). In reality, this problem is often trivial considering the limited number of intermodal points. To move from point a to b, with or without intermodality, two global constraints are taken into account by the users of the network: the time and the costs of travel. This assumption is quite simple but highly realistic. Travel time over a transportation chain ($t_{\{a \rightarrow b\}}$) is expressed by:

$$t_{\{a-b\}} = \sum_{\forall T^X_{ab} \in \{a-b\}} t\left(T^X_{ab}\right) + \sum_{\forall T^{XY}_a \in \{a-b\}} t\left(T^{XY}_a\right) \tag{7}$$

Travel time over a transportation chain is the sum of travel times along arcs in that transportation chain ($t(T^X_{ab})$) and of intermodal times in that same transportation chain ($t(T^{XY}_a)$). Travel time along an arc is expressed by:

$$t\left(T^X_{ab}\right) = f\left(v^X_{ab}, d_{ab}, i^X_{ab}, e^{t(T^X_{ab})}_{ab}\right) \tag{8}$$

where: v^X_{ab} = speed between point a and point b for modal network X.
d^X_{ab} = distance between point a and point b for modal network X.
i^X_{ab} = capacity of the modal infrastructures between point a and point b of network X.
$e^{t(T^X_{ab})}_{ab}$ = externalities related to travel time between a and b for modal network X.

Intermodal time for an intermodal arc is expressed by:

$$t(T_a^{XY}) = f\left(h^m, i_a^{XY}, Q^m, e_a^{t(T_a^{XY})}\right) \quad (9)$$

where: h^m = handling capacity of the good m.
i_a^{XY} = capacity of the intermodal infrastructure between modal networks R^X and R^Y at point a.
Q^m = quantity of good m.
$e_a^{t(T_a^{XY})}$ = externalities related to intermodal time at point a.

Equations 8 and 9 underline the notion of externalities that influence travel and intermodal time. For instance, port congestions can expand the travel time because a ship have to wait several days to be unloaded. This is a major problem of port areas that serve as main intermodal centres. To the notion of travel time we add the notion of travel costs over a transportation chain ($c_{(a\to b)}$):

$$c_{(a\to b)} = \sum_{\forall T_{ab}^X \in (a\to b)} c(T_{ab}^X) + \sum_{\forall T_a^{XY} \in (a\to b)} c(T_a^{XY}) \quad (10)$$

Travel costs over a transportation chain is the sum of travel costs along arcs of the transportation chain $c(T_{ab}^X)$ and the sum of intermodal costs for all element of a transportation chain $c(T_a^{XY})$. Travel costs along an arc are expressed by:

$$c(T_{ab}^X) = f\left(d_{ab}, Q^m, h^m, e_{ab}^{c(T_{ab}^X)}\right) \quad (11)$$

where: $e_{ab}^{c(T_{ab}^X)}$ = externalities related to travel costs between a and b.

Intermodal costs for an intermodal arc take the form of:

$$c(T_a^{XY}) = f\left(Q^m, c(i_a^{XY}), e_a^{c(T_a^{XY})}\right) \quad (12)$$

where: $c(i_a^{XY})$ = costs of use of the intermodal infrastructures at point a.
$e_a^{c(T_a^{XY})}$ = externalities related to intermodal costs at point a.

Externalities involving travel costs between two points can be related for instance to insurance and custom fees while externalities involving intermodal costs can be related to storage costs. There are two types of problems involving the time and costs of transportation in a multimodal network. First, problems of senders that rest on the choice of a transportation chain $\{a\to b\}$ between two points with a fixed origin, destination, quantity and value of the good. Second, problems of operators who must maximize the global efficiency of the multimodal network considering the transportation demand of senders and infrastructures they have access to ($\{a\to b^*\}$). In both cases, the goal for a multimodal network is to minimize the time and costs of transportation for all transportation chains included in R. This is maximizing the multimodal network efficiency ($E_{(a\to b)^*}$):

$$\max : (E_{(a\rightarrow b)^*}) = \left[\min : (t_{ab}) , \min : (c_{ab})\right] \forall \{a\rightarrow b\}^* \quad (13)$$

Or:

$$\max : (E_{(a\rightarrow b)^*}) = \left[\min : \left(t(T_{ab}^X) , t(T_a^{XY})\right) , \min : \left(c(T_{ab}^X) , c(T_a^{XY})\right)\right] \forall \{a\rightarrow b\}^* \quad (14)$$

Most of the time, a sender has just one transportation chain to optimize while an operator has several. For some goods like perishable and high technology goods, the aim is to reduce travel time, while for other goods like minerals, transportation costs must be minimal even if the travel time is extended. In most cases, a minimization of travel time and travel cost is jointly searched. With the pre-existence and the permanent character of several transportation networks like air and maritime lines, the main goal of operators is to limit the time and costs of intermodality and find alternative routes. By including equations 8,9, 11 and 12 to equation 14, we have:

$$\begin{aligned} &\max : (E_{(a\rightarrow b)^*}) = \\ &\max : \left(Q^m , h^m , i_a^{XY}\right) , \min : \left(c(i_a^{XY}) , e_{ab}^{c(T_{ab}^X)} , e_a^{c(T_a^{XY})}\right) , \\ &\max : \left(v_{ab}^X , i_{ab}^X\right) , \min : \left(d_{ab} , e_{ab}^{t(T_{ab}^X)} , e_a^{t(T_a^{XY})}\right) \forall \{a\rightarrow b\}^* \end{aligned} \quad (15)$$

All the parameters of this equation are constraints so the general objective of multimodal planning is to overcome the limitations of the transportation system. The maximization of the quantity of goods (Q^m) is achieved by using large carriers that give economies of scale. This is also done by making specific traffic converge to high capacity intermodal centres, thus specializing the function of ports. If the quantity of goods exceed the capacity of the modal or intermodal infrastructures, congestions occur. The maximization of the handling capacity of goods (h^m) is done through the standardization of the load. Containers are the most recent achievement of that process. Maximizing the capacity of the intermodal infrastructures (i_a^{XY}) is generally done by investments in fixed transportation infrastructures like ports and airports. However investments on those types of transportation infrastructures are costly and considered most of the time as the last alternative to escape congestion. The minimization of costs and travel time extension by externalities for modal and intermodal transportation (e_{ab}^c , e_{ab}^t , e_a^c and e_a^t) is done by a better management of a multimodal network. This means for instance that a shipment arrives at a port when unloading infrastructures are available. Several externalities have costs and time extensions that are difficult to escape like congestion costs and time. The maximization of speed (v_{ab}^k) implies investments in more efficient vehicles and new transportation technologies. Maximizing the capacity of a modal network (i_{ab}^X) require investment in infrastructures like highways and railways. For the maritime and air transportation the capacity of the network is often limited by the capacity of the intermodal infrastructures, that is i_a^{XY}. Minimizing distance (d_{ab}) is very difficult to overcome because of the existing physical constraints and fixed international transportation corridors. It is important to understand that equation 15 does not explain the generation of movement between economic zones, but how transportation plays a role in initiating, orienting or maintaining the process of spatial accumulation and economic development to specific areas. We suggest that the maximization of the multimodal transportation network efficiency ($E_{(a\rightarrow b)^*}$) has too much parameters to be solved by conventional operations research techniques. Operators often use their experience and judgement to "minimize" or "maximize" several parameters. Maximizing or minimizing one or several parameters of equation 15 in no way enable an optimization of a transportation system. At most a functional state is reached.

Following the development of the theoretical aspects of intermodality, those notions will be applied to the process of emergence of mega-urban regions to demonstrate in what way intermodality influence complex transportation / land use processes.

4. Intermodality in the Emergence of Mega-Urban Regions

The process of emergence of mega-urban regions is strongly related to the development of trade relations, inside and outside the region. The mega-urban region is integrated in a complex multimodal transportation network that was defined in the previous section.

4.1 Intermodal Aspects

Figure 4.1 presents an hypothetical geometrical aspect of intermodality in the theoretical mega-urban region of figure 2.2. The multimodal network can be understood as two interacting transportation systems: external and internal. The linkages between internal and external transportation systems are done at main intermodal centres.

The external transportation system is composed of the infrastructures and the linkages that enable the mega-urban region to convey goods, people and information with other economic areas. Every input and output of the mega-urban region must transit trough those infrastructures. The infrastructures supporting that system are mainly the ports and airports, and the linkages are the maritime and airway lines. When a mega-urban region is on the same land mass as another economic area, land transportation is added as a linkage. The importance of the external transportation system in a mega-urban region is related to the location of the region relative to other economic areas and its internal economic dynamic. Both factors are highly interdependent since the dynamic of an economic space influence and is influenced by socio-economical conditions as well as transportation capacity to support the raising productivity of the mega-urban region.

The internal transportation system is the set of transportation infrastructures and linkages that give the mega-urban region a capacity to convey movements inside the system. The spatial cover of the internal transportation system defines the spatial cover of the mega-urban region. The most typical form of this system is a corridor along which are concentred the main urban areas and transportation infrastructures. On figure 4.1 there is a linear corridor of economic development between city *a* and city *c*. The importance of intermodality in the internal transportation system is related to the level of accessibility it convey. At the regional scale, economic development occurs at the most accessible places. So it is likely that the process of spatial accumulation will be more intense near accessible places.

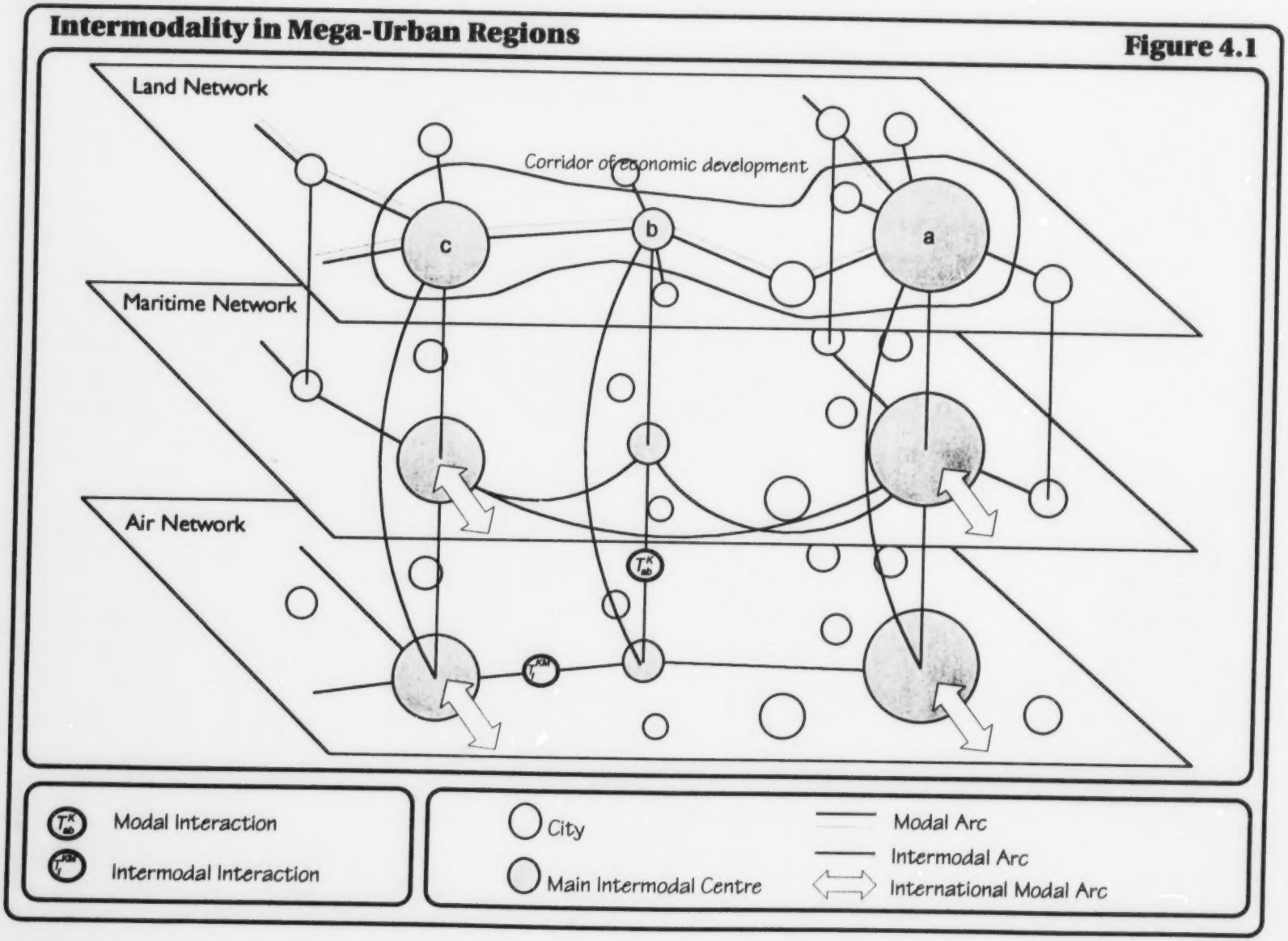
4.2 A Case Study: Nanjing-Shanghai-Hangzhou

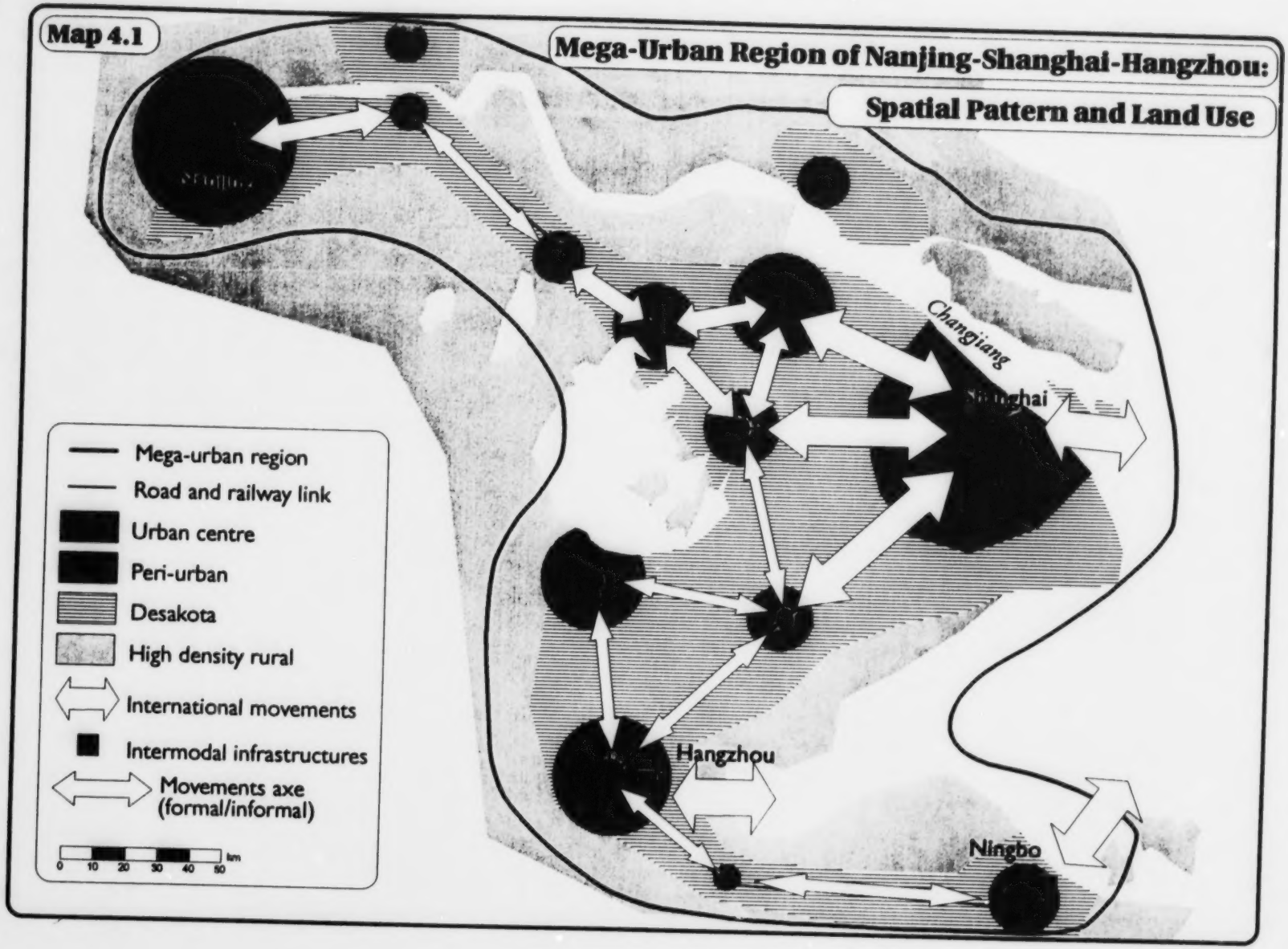
China has four mega-urban regions where the emergence of *desakota* is intensive. All those mega-urban regions are located in coastal plains and two are in deltaic region, Hong Kong-Guangzhou-Macau and Nanjing-Shanghai-Hangzhou. This geographical characteristic offers a supplementary transportation axe that facilitate movements of goods inside the mega-urban region. Chinese planning policies oriented toward the development of coastal zones let foresee important changes inside the national urban system, particularly at the level of the investments in transportation infrastructures (Comtois, 1989). However to lessen regional disparities, this policy of coastal development is gradually apply to mainland cities, particularly along the Changjiang. The main intermodal centres of the Chinese coast are Dalian, Tianjin, Shanghai and Hong Kong. Each of those metropolitan areas is the anchor of a mega-urban region.

The four chinese mega-urban regions account for 2.52% of the surface, but for 12.53% of the population and for 46.42% of the industrial production of China. Even if those regions are the most urbanized and industrialized, they have a share of the agricultural production superior to their demographic share (13.08% against 12.53%). It seems that mega-urban regions are emerging in the most accessible areas of China where foreign investments are likely to be more productive. The mega-urban region of Nanjing-Shanghai-Hangzhou is the most important of China with only 1.4% of the surface, but 6.5% of the population an 27.1% of the industrial production. It covers parts of the provinces of Jiangsu and Zhejiang and the municipality of Shanghai.

Map 4.1 shows the spatial pattern and land use of the mega-urban region. The urban areas are the main factor that structure the mega-urban region. Three centres have intermodal infrastructures, Shanghai, Hangzhou and Ningbo. In our case study, the mega-urban region is a linear corridor were the accessibility level to the regional an international markets is high. Linear mega-urban regions limits the number of potential transportation chain by concentrating the transportation infrastructures along a single corridor. Intermodality is one component of the regional accessibility level like the accessibility level to a transportation mode.

Intermodality in Mega-Urban Regions **Figure 4.1**




Map 4.1
Mega-Urban Region of Nanjing-Shanghai-Hangzhou:
Spatial Pattern and Land Use
Changjiang
Hangzhou
Ningbo
Mega-urban region
Road and railway link
Urban centre
Peri-urban
Desakota
High density rural
International movements
Intermodal infrastructures
Movements axe (formal/informal)
0 10 20 30 40 50 km

5. Conclusion

This paper has underlined the notion of intermodality and its role in the emergence of mega-urban regions in East Asia. Intermodality occurs in a three dimensional transportation space where the first dimension is the spatial entities (points), the second dimension is the modal interactions, and the third dimension is the intermodal interactions. The global objective of operators is to minimize transportation time and costs. This involves the selection of a set of transportation chains that presents the least travel time and/or cost over all the potential transportation chains. Intermodality offers a partial answer to the objective of minimization of time and costs by permitting a higher fluidity of movements.

Intermodal infrastructures are at the base of the development of mega-urban regions because they are the only locations where a link from a regional urban system towards other economic entities is possible. In other words, the production of a large economic area must transit at a limited number of nodes, if not only one. Between major intermodal centres that are metropolitan areas, corridors of economic development emerge. Those corridors are characterized by important land use changes from rural to non-rural activities, forming an intense mixture of activities defined as *desakota* regions. The result is an important growth of transportation demand and congestion on limited modal and intermodal infrastructures.

Present knowledge of intermodality, and more particularly transportation role in the emergence of mega-urban region in East Asia is only partial. For instance, to what extent transportation is a factor of concentration or dispersion of economic activities? The first step towards a better comprehension of the complex spatial processes occurring in those regions is the development of new theoretical backgrounds, spatial models and methodologies, which was the aim of this paper. Field surveys are necessary in order to gather data and information to help the planning of the transportation / land use system of those complex economic entities.

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